

What is claimed is:

1 1. A communications network comprising:
2 a plurality of transmission links; and
3 a plurality of nodes for interconnecting said links to form a working
4 ring and a protection ring in a ring topology, and establishing a plurality of
5 working paths on said working ring and a plurality of protection paths on
6 said protection ring corresponding to said plurality of working paths,
7 one of said working paths spanning across first and second nodes of
8 said plurality of nodes for transmission of a signal in a first direction of said
9 ring topology,
10 one of said protection paths spanning across said first and second
11 nodes for transmission of a signal in a second direction of said ring
12 topology opposite to said first direction,
13 said first and second nodes normally using said one working path
14 and being responsive to a failure of said one working path for using said
15 one protection path instead of said one working path.

1 2. A communications network comprising:
2 a plurality of transmission links; and
3 a plurality of nodes for interconnecting said transmission links to
4 form first and second working rings and first and second protection rings
5 in a ring topology, and establishing a plurality of working paths on each of
6 said working rings and a plurality of protection paths on each of said
7 protection rings corresponding to said plurality of working paths,
8 a first one of said working paths of said first working ring spanning
9 across first and second nodes of said plurality of nodes for transmission of
10 a signal in a first direction of said ring topology,
11 a second one of said working paths of said second working ring
12 spanning across the first and second nodes for transmission of a signal in a
13 second direction of the ring topology opposite to the first direction,
14 a first one of said protection paths on said first protection ring

15 spanning across the first and second nodes for transmission of a signal in
16 said second direction of said ring topology,
17 a second one of said protection paths of said second protection ring
18 spanning across the first and second nodes for transmission of a signal in
19 said first direction of said ring topology,
20 said first and second nodes normally using said first and second
21 working paths, respectively, and being responsive to a failure of one of said
22 first and second working paths for using a corresponding one of the first
23 and second protection paths instead of the failed working path.

1 3. A communications network comprising:
2 a plurality of transmission links; and
3 a plurality of nodes for interconnecting said links to form a working
4 ring and a protection ring in a ring topology, and establishing a plurality of
5 working paths on said working ring and a plurality of extra traffic paths on
6 said protection ring,
7 one of said working paths spanning across first and second nodes of
8 said plurality of nodes for transmission of a signal in a first direction of said
9 ring topology,
10 one of said extra traffic paths spanning across said first and second
11 nodes for transmission of a low-priority signal in a second direction of said
12 ring topology opposite to said first direction,
13 said first and second nodes normally using said one working path
14 and being responsive to a failure of said one working path for clearing said
15 one extra traffic path to establish a first protection path and using the first
16 protection path, clearing other extra traffic paths to establish a second
17 protection path if said first protection path is not successfully established
18 and using said second protection path instead of the failed working path,
19 said first protection path having a shorter length than said second
20 protection path.

1 4. A communications network as claimed in claim 2, wherein first

2 and second working paths of said plurality of working paths are assigned a
3 first network resource and first and second protection paths of said
4 plurality of protection paths are assigned a second network resource,
5 said first node normally using said first network resource and said
6 first working path and being responsive to a failure in said first ring for
7 using said second network resource and said second protection path
8 instead of said first network resource and said first working path,
9 said second node normally using said second network resource and
10 said second working path and being responsive to a failure of the second
11 ring for using said first network resource and said first protection path
12 instead of the second network resource and the second working path.

1 5. A communications network as claimed in claim 2, wherein first
2 and second working paths of said plurality of working paths are assigned
3 first and second network resources, respectively, and first and second
4 protection paths of said plurality of protection paths are assigned said
5 second and first network resources, respectively,
6 said first node normally using said first network resource and said
7 first working path and being responsive to a failure of said first ring for
8 using said second protection path instead of said first working path,
9 said second node normally using said second network resource and
10 said second working path and being responsive to a failure of the second
11 ring for using the first protection path instead of the second protection path.

1 6. A communications network as claimed in claim 4 or 5, wherein
2 said first and second network resources are optical energy of different
3 wavelengths.

1 7. A communications network as claimed in claim 1, 2, 3, 4 or 5,
2 wherein said first node is arranged to detect said failure and transmit a
3 command signal to said second node for instructing the second node to
4 switch from said one working path to said one protection path.

1 8. A communications network as claimed in claim 7, wherein said
2 first node is a destination node.

1 9. A communications network as claimed in claim 7, wherein said
2 command signal is transmitted in format in which bit positions represent
3 information.

1 10. A communications network as claimed in claim 1, 2, 3, 4 or 5,
2 wherein each of said first and second nodes comprises:
3 a first demultiplexer for receiving a multiplex signal from said one
4 working path for producing drop-off signals;
5 a first multiplexer for multiplexing add-up signals onto said one
6 working path;
7 a first path switch connected between said first demultiplexer and
8 said first multiplexer;
9 a second demultiplexer for receiving a multiplex signal from said
10 one protection path for producing drop-off signals;
11 a second multiplexer for multiplexing add-up signals onto said one
12 protection path;
13 a second path switch connected between said second demultiplexer
14 and said second multiplexer;
15 a transmit protection switch;
16 a receive protection switch; and
17 control circuitry for monitoring said one working path and
18 controlling said transmit protection switch so that one of said add-up
19 signals is coupled to said first multiplexer when no failure is detected in
20 said one working path and coupled to said second multiplexer when a
21 failure is detected in said one working path, and controlling said receive
22 protection switch so that one of said drop-off signals of said first
23 multiplexer is received when no failure is detected in said one working
24 path and one of said drop-off signals of said second multiplexer is received
25 when said failure is detected.

1 11. A communications network as claimed in claim 10, wherein
2 said control circuitry is arranged to exchange control signals with adjacent
3 nodes for controlling said transmit and receive protection switches.

1 12. A communications network as claimed in claim 10, wherein
2 each of said first and second demultiplexers comprises an optical
3 demultiplexer and each of said first and second multiplexers comprises an
4 optical multiplexer.

1 13. A communications network as claimed in claim 10, wherein
2 said transmit protection switch includes first and second output ports
3 associated with ones of said working paths and third and fourth output
4 ports associated with ones of said protection paths,
5 said transmit protection switch being responsive to a control signal
6 from said control circuitry for coupling two add-up signals to said first and
7 second output ports respectively and coupling each one of said two add-up
8 signals to one of the third and fourth ports,
9 wherein said receive protection switch includes first and second
10 input ports associated with ones of said working paths and third and fourth
11 input ports associated with ones of said protection paths,
12 said receive protection switch being responsive to a control signal
13 from said control circuitry for receiving two drop-off signals from said first
14 and second input ports and receiving each one of the drop-off signals from
15 one of the third and fourth input ports.

1 14. A communications network as claimed in claim 11, wherein
2 said transmit protection switch comprises:
3 first, second, third and fourth optical couplers respectively
4 connected to said first, second, third and fourth output ports; and
5 first, second, third and fourth optical switches, said first optical
6 switch having outputs respectively coupled to said first, third and fourth
7 optical couplers, said second optical switch having outputs respectively

8 coupled to said second, third and fourth optical couplers, said third optical
9 switch having outputs coupled respectively to said first and third optical
10 couplers, and said fourth optical switching having outputs respectively
11 coupled to said second and fourth optical couplers.

1 15. A communications network as claimed in claim 11, wherein
2 said receive protection switch comprises:
3 first, second, third and fourth optical couplers respectively
4 connected to said first, second, third and fourth input ports; and
5 first, second, third and fourth optical switches, said first optical
6 switch having inputs respectively coupled to said first, third and fourth
7 optical couplers, said second optical switch having inputs respectively
8 coupled to said second, third and fourth optical couplers, said third optical
9 switch having inputs coupled respectively to said first and third optical
10 couplers, and said fourth optical switching having inputs respectively
11 coupled to said second and fourth optical couplers.

1 16. A communications network as claimed in claim 14, wherein
2 said transmit protection switch further comprises:
3 a fifth optical coupler having outputs respectively connected to
4 said first and third optical switches; and
5 a sixth optical coupler having outputs respectively connected to
6 said second and fourth optical switches.

1 17. A communications network as claimed in claim 15, wherein
2 said receive protection switch further comprises:
3 a fifth optical coupler having inputs respectively connected to said
4 first and third optical switches; and
5 a sixth optical coupler having inputs respectively connected to said
6 second and fourth optical switches.

1 18. A network node for a ring topology network, the network

2 having first and second working rings and first and second optical
3 protection rings in a ring topology, and a plurality of working paths on
4 each of said working rings and a plurality of protection paths on each of
5 said protection rings corresponding to said plurality of working paths,
6 the network node comprising:
7 a first demultiplexer for receiving a multiplex signal from one of the
8 working paths for producing drop-off signals;
9 a first multiplexer for multiplexing add-up signals onto said one
10 working path;
11 a first path switch connected between said first demultiplexer and
12 said first multiplexer;
13 a second demultiplexer for receiving a multiplex signal from one of
14 said protection paths for producing drop-off signals;
15 a second multiplexer for multiplexing add-up signals onto said one
16 protection path;
17 a second path switch connected between said second demultiplexer
18 and said second multiplexer;
19 a transmit protection switch;
20 a receive protection switch; and
21 control circuitry for monitoring said one working path and
22 controlling said transmit protection switch so that one of said add-up
23 signals is coupled to said first multiplexer when no failure is detected in
24 said one working path and coupled to said second multiplexer when a
25 failure is detected in said one working path, and controlling said receive
26 protection switch so that one of said drop-off signals of said first
27 multiplexer is received when no failure is detected in said one working
28 path and one of said drop-off signals of said second multiplexer is received
29 when said failure is detected.

1 19. A network node as claimed in claim 18, wherein said control
2 circuitry is arranged to exchange control signals with adjacent nodes for
3 controlling said transmit and receive protection switches.

1 20. A network node as claimed in claim 18, wherein each of said
2 first and second demultiplexers comprises an optical demultiplexer and
3 each of said first and second multiplexers comprises an optical multiplexer.

1 21. A network node as claimed in claim 18, wherein said
2 transmit protection switch includes first and second output ports associated
3 with ones of said working paths and third and fourth output ports
4 associated with ones of said protection paths,
5 said transmit protection switch being responsive to a control signal
6 from said control circuitry for coupling two add-up signals to said first and
7 second output ports respectively and coupling each one of said two add-up
8 signals to one of the third and fourth ports,
9 wherein said receive protection switch includes first and second
10 input ports associated with ones of said working paths and third and fourth
11 input ports associated with ones of said protection paths,
12 said receive protection switch being responsive to a control signal
13 from said control circuitry for receiving two drop-off signals from said first
14 and second input ports and receiving each one of the drop-off signals from
15 one of the third and fourth input ports.

1 22. A network node as claimed in claim 21, wherein said
2 transmit protection switch comprises:
3 first, second, third and fourth optical couplers respectively
4 connected to said first, second, third and fourth output ports; and
5 first, second, third and fourth optical switches, said first optical
6 switch having outputs respectively coupled to said first, third and fourth
7 optical couplers, said second optical switch having outputs respectively
8 coupled to said second, third and fourth optical couplers, said third optical
9 switch having outputs coupled respectively to said first and third optical
10 couplers, and said fourth optical switching having outputs respectively
11 coupled to said second and fourth optical couplers.

1 23. A network node as claimed in claim 21, wherein said receive
2 protection switch comprises:
3 first, second, third and fourth optical couplers respectively
4 connected to said first, second, third and fourth input ports; and
5 first, second, third and fourth optical switches, said first optical
6 switch having inputs respectively coupled to said first, third and fourth
7 optical couplers, said second optical switch having inputs respectively
8 coupled to said second, third and fourth optical couplers, said third optical
9 switch having inputs coupled respectively to said first and third optical
10 couplers, and said fourth optical switching having inputs respectively
11 coupled to said second and fourth optical couplers.

1 24. A network node as claimed in claim 22, wherein said
2 transmit protection switch further comprises:
3 a fifth optical coupler having outputs respectively connected to
4 said first and third optical switches; and
5 a sixth optical coupler having outputs respectively connected to
6 said second and fourth optical switches.

1 25. A network node as claimed in claim 23, wherein said receive
2 protection switch further comprises:
3 a fifth optical coupler having inputs respectively connected to said
4 first and third optical switches; and
5 a sixth optical coupler having inputs respectively connected to said
6 second and fourth optical switches.

1 26. A fault recovery method for a communications network,
2 wherein the network comprises a plurality of transmission links, and a
3 plurality of nodes for interconnecting said links to form a working ring and
4 a protection ring in a ring topology, and establishing a plurality of working
5 paths on said working ring and a plurality of protection paths on said
6 protection ring corresponding to said plurality of working paths, the

7 method comprising the steps of:

- 8 a) establishing one of said working paths between source and
9 destination nodes of said plurality of nodes for transmission of a signal in a
10 first direction of said ring topology and establishing one of said protection
11 paths between said source and destination nodes for transmission of a
12 signal in a second direction of said ring topology opposite to said first
13 direction;
- 14 b) using said one working path for communication between said
15 source and destination nodes;
- 16 c) monitoring said working path at said destination node;
- 17 d) transmitting a switching command message from said
18 destination node to said source node if a failure is detected in said working
19 path; and
- 20 e) using said one protection path for communication between
21 said source and destination nodes, instead of the failed working path, in
22 response to said switching command message.

1 27. A fault recovery method for a communications network,
2 wherein the network comprises a plurality of transmission links, and a
3 plurality of nodes for interconnecting said links to form a working ring and
4 a protection ring in a ring topology, and establishing a plurality of working
5 paths on said working ring and a plurality of extra traffic paths on said
6 protection ring, the method comprising the steps of:

- 7 a) establishing one of said working paths between source and
8 destination nodes of said plurality of nodes for transmission of a signal in a
9 first direction of said ring topology and establishing one of said extra traffic
10 paths between said source and destination nodes for transmission of a low-
11 priority signal in a second direction of said ring topology opposite to said
12 first direction,
- 13 b) normally using said one working path between said source
14 and destination nodes;
- 15 c) monitoring said one working path at said destination node;

16 d) clearing said one extra traffic path to establish a short-haul
17 protection path between said source and destination nodes when a failure
18 is detected in said one working path and using the short-haul protection
19 path, instead of the failed working path, between said source and
20 destination nodes; and

21 e) clearing other extra traffic paths to establish a long-haul
22 protection path if said short-haul protection path is not successfully
23 established and using said long-haul protection path, instead of the failed
24 working path, between said source and destination nodes.